Vol. V. No. 55 DECEMBER, 1941

Plastics

Dealing with the Manufacture, Uses and Potentialities of Plastic Materials

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Federation Meeting

THE meetings of trade and similar federations, those communities which exist for general advancement and mutual protection against the wolves of the outer world, are generally distinguished for the loud expression of eternal love between individual members and the complete lack of real excitement.

The annual general meeting of the British Plastics Federation, at whose lunch we were guests last month, was different. Moreover, it was noteworthy for several other reasons—a record attendance during war-time, a record in membership (it has increased to about 160 members), and the admirable speech of its chairman, Major Mohr, O.B.E., M.C.

In a sense, we were regarding a strange and solemn scene, obviously not solemn on the surface. Three short years ago each and every member had been engaged in turning out, rarely to the capacity of their presses, a number of objects for a variety of peaceful industries, and of whose value the Government was either in ignorance or did not believe. In this short period the scene is completely changed. The plastics industry has become as important as any metal industry, differing only in the mass it can at present produce. It is a war industry and every member-factory of the Federation is a war factory. With the presence of the Plastics Controller and his aides at the Savoy lunch, we had here the fairly complete entity we had long ago looked for—the Government, the factories and the organization to knit them together in a workable form.

It has taken a war to straighten out some of the main problems of the plastics industry, and it would be little short of a calamity if the lessons learnt during these times of trouble were not remembered in peace-time.

The president's speech was distinguished in several important ways. He can coo as well as any dove, but he can also roar as well as any lion. He is the first president to say, albeit not the first to think, that the plastics industry is more than a mere parochial affair; nor need it, in peace-time, be a collection of individuals in which one man's hand is always against the other's. For that way spells disaster.

We began this note by saying that trade meetings are rarely exciting. Major Mohr's speech contained one thought which made us catch our breath and made us wonder how the remainder of the audience had received it. His plea for closer co-operation within the industry led him to the necessity for horizontal integration—that much closer union of individuals working in the same field.

Doubtless he was thinking of the peace that followed the last war; of the reasonably successful struggle to co-ordinate our industries so that they could face international competition, and of the schemes of "rationalization," both vertical and horizontal, that followed. At that period, roughly between 1925 and 1930, we were observing the process taking place in the chemical industry. It was a fascinating process as well as nationally important. There were big ideas behind it, by no means ideas merely to control methods of making money. Basically, the biggest was the creation of a strong industry, vital to the British Empire, a union that for the first time could stand on its feet and talk to the great German chemical industry in its own language. Prior to 1914, for example, 95 per cent. of our dyestuffs were imported from Europe. By 1930, 95 per cent. of our dyestuffs were made in this country. Rationalization, aided by a wise Government, had secured the life of one of our vital industries.

We believe that Major Mohr sees in the plastics industry something that is vastly important to the British Empire, and that a time will come when it will be necessary for the plastics industry to be able to speak with one voice—and a powerful one at that—against the forces that are bound to grow after the war. It must not be permitted, for example, that loads of foreign mouldings be foisted on this country merely because they are cheaper than those made here. Again, a powerful combination would be able not only to improve the internal economy of the industry, but would also be able to further research, a branch which is so poorly developed in the moulding industry itself.

Nevertheless this aspect of modern industrial economy is wont to send a shiver down the backs of many, but it is far from being all-embracing, and, by and large, the advantages generally outweigh the disadvantages. It is generally

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assumed that the "little man" suffers, but this is rarely true. The small factory, by virtue of its very smallness, is able, by concentrating on its own problems, to achieve an efficiency often unsurpassed by the largest of concerns. This is a matter of everyday occurrence, and depends merely on individual hard work, genius, call it what you will. The small concern can also be far more elastic, less cumbersome and less tied down to red tape than the great company. Nothing can ever stifle thought, and scientific ability is not the prerogative of big money.

But while we are the champions of the small factory, we are not the champions of the small, inefficient factory whose existence depends merely on the ability to cut down fair overheads and fair profit.

Rationalization of the horizontal integration type described by Major Mohr is not our ideal of industrial life. But that it is a realistic view of the present and future needs of industry as it exists, cannot be doubted. As we have said before, it is never, and cannot be, all-embracing, but it does provide the keystone around which a strong edifice can be raised, an edifice which will not fall to pieces by the mere blowing of a trumpet.

NEW LIGHT IN DARK PLACES. On another page we publish some further notes on what is now called curved light—more correctly the transmission of light through curved forms of transparent methyl methacrylate.

So far, the only section of human endeavour that has taken advantage practically of this rare phenomenon is medical science. Why this is so, is not quite clear, for the basic problem of projection of light at a definite point remote from its source is not the prerogative of surgery, although its importance here cannot be minimized.

Surely there is also a field in the industrial world. We believe most chemists and engineers could put their fingers on many applications. If we can now look inside a man's stomach, which, after all, is only a rather magnificent piece of engineering, there are certainly other obscure places which would always be the better for a little light.

The advantages to industry are in the main similar to those gained in surgery. Light is required at an optimum intensity at a point and not, for example, behind one's head or at such a distance that the candle power is negligible. We imagine that a watch or instrument maker would find a pencil point of light directed at his work and away from his eyes immeasurably useful and healthful. So too would the tool maker and, in these days of complicated hollow machined objects in the war industries, the ubiquitous examiner.

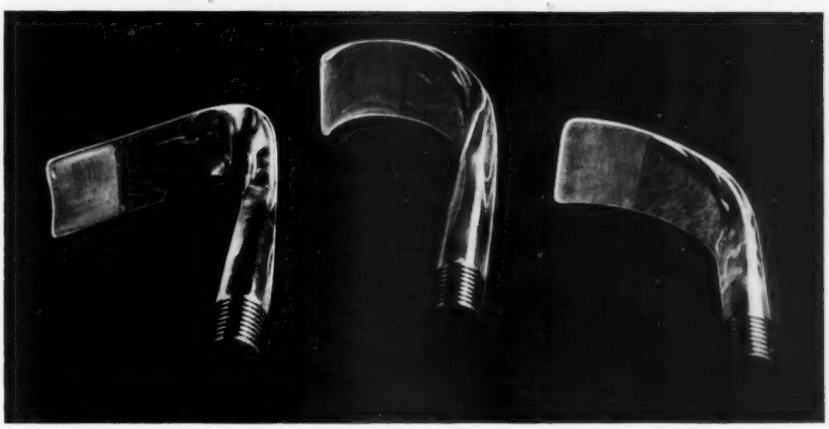
That curved light is cold at the point of exit is an advantage, not so great, perhaps, to the industrial worker as to a patient undergoing medical examination, but in what might be called dangerous operations it might become extremely important. There are probably many points, for example in an explosives factory or ether or alcohol plant, where cold light reasonably remote from the source of electricity might prove of high value. The heavy, cumbersome electric lamps which are especially designed for such dangerous work could often be replaced by a methacrylate bar curling away into safety. People who play with our new super explosive and mercury fulminate, or take samples of petrol from the tops of million-gallon tanks in the dark, please note. There are limits, we presume, placed on the distance light can thus be carried, for some is lost en route, but it is not very short. Curved rods 4 ft. long have been used and we believe the complete surround of a motorcar exhibition stand has been made. It will be interesting to note if, in peace-time, this type of light can be made to supplant "neon." The costly high-voltage transformer is not necessary and curious effects can be obtained by "waving" the light at source and by grinding the surface of the resin at intervals along its length.

RINGING THE CHANGES. We were extremely interested to hear from a director of Vann Bros., one of the companies making such "curved light" instruments, that a "boilable" variety is now available. While we expressed our astonishment at the statement, we were assured that this was so—the fact seems to be corroborated by eminent medical authorities. The ability thus to sterilize surgical instruments made from this resin has already been claimed, but boiling has always had a cumulative effect with the resultant softening we know so well.

Within a stone's-throw of this factory and still within the holy medical circle around Harley Street, we discovered yet another works employing methyl methacrylate resin. Here it was the normally less exciting dental industry. Portland Plastics, Ltd., however, are far from being a normal denture-making company, for it has undertaken much chemical and physical research on methyl methacrylate, resulting in the production of what can be called two entirely novel derivatives or forms of the resin. The first of note is a rubbery polymethylmethacrylate (the synthetic resin is probably modified with pure rubber) and, while retaining many of the excellent properties of the resin, is of value primarily for the production of dental plates where resilience is desired. The second, and probably the more interesting, is a hollow spherical type, each sphere being of the order of $\frac{1}{100}$ in. in diameter. The smallness of the spheres and the fact that they are hollow make them something more than of amusing or academic interest. Moulded, this "powder" becomes a strong structure, with a specific gravity varying from, say, 0.2 to 0.6 according to the pressure, impervious to water (the top and bottom surfaces are sealed) and of extremely low heat conductivity since intermediate spheres retain their hollowness. First utilized for dental work because of its lightness, it will probably find many other applications in industry.

ON SAVING GAS.—It is strange that, in the otherwise praiseworthy movement now sweeping the country for preventing needless waste, due consideration is not always given to problems that might lie behind a so-called saving. The drive for fuel economy is a case in point. The cutting down of electric light is a real saving for it is made from coal more or less directly by burning and similarly so is electrical heating, if discomfort is not considered important. Gas usage, however, is in somewhat a different category, for it is a product bound up with others derived from coal, many of which are vitally important to the war effort. If gas production is cut down, then so, ipso facto, less of these other materials are produced. The whole subject of so-called gas-wastage is reviewed by a chemical engineer in a recent issue of the "Glasgow Herald" and some of his points are worth noting here. After dealing with the fallacy of gas-saving by the housewife, he points to the less obvious aspect we mention above. For each 1,000 "therms" saved, the country loses 4 cwt. of ammonium sulphate, invaluable as a fertilizer to the farmer. Alternatively, the ammonia can be used for making explosives. In addition, 5 lb. of toluene used to make T.N.T., and 20 lb. of benzene for dyestuffs, phenol or medicinal products, are lost. A further 10 lb. of phenol and 20 lb. of cresol are lost because no tar is available in saving these 1,000 therms, and without phenol and cresol—where should we be?

AND SAVING PAPER. Here we have a real method of helping the country's economy. The plastics industry, with the exception of one concern, cannot, it is true, turn out its old files of 1880, but it has out-of-date catalogues and other stores of needless paper which can go to the collector. There is no other use of old paper but to repulp it into new. It may not reappear as the high-quality material used for the manufacture of laminated plastics, but it is being made into hundreds of things destined for the war effort. So save your paper!



Range of Curvlite attachments for abdominal retractors and other instruments.

Methyl Methacrylate resin with its valuable property of light transmission has placed a powerful weapon in the hands of Medical Science

Surgery and Cold Curved Light

ABOUT three years ago we published some of the early information that was available on the subject of curved light through transparent plastics. Since that time considerable progress has been reported, and as war-time is usually associated with a more or less complete cessation of peace-time research, this progress is as heartening as it is praiseworthy. Moreover, advances in medical science must of necessity be so carefully controlled—the demands generally outweigh by far those of any other science—that more than normal praise is due to the manufacturers of the transparent resin and to the fabricators therefrom of the surgical instruments. During a recent visit to Messrs. Vann Bros., of 63, Weymouth Street, W.1, who were the first instrument makers in this country to develop the use of plastics in the manufacture of surgical instruments, the directors expressed to the writer their gratitude for the unstinted help given them by I.C.I. (Plastics), Ltd., the manufacturers of the material that is used for the fabrication of "cold light" appliances.

The readers of this journal may be reminded of the main points that have already been made in these pages. Methyl methacrylate resin possesses to a very high degree the ability to transmit light round curves. It has a high refractive index, and there is considerable internal reflection from the highly polished surface. This property is not unique to this resin, since both glass and quartz can be made to transmit light in a curve, but both these latter are difficult to fabricate, having many other disadvantages. In the case of quartz, it is impossible to obtain in large enough pieces, and fabrication of surgical instruments is out of the question.

Rods of methyl methacrylate in obtuse or acute angles or even if tied in a knot will transmit light applied at one end to issue at the other end. Little light escapes between unless the walls are roughened. This roughening by grinding is carried out at the point where the maximum emission of light is required, generally at the end of the rod.

Advantage of Cold Curved Light Instruments

Since light itself is of fundamental importance in surgical operation, we see in methyl methacrylate resin one of the most important tools in the hands of the surgeon. We can make a preliminary list of advantages for the material as follows:—

1. Since this resin is a non-conductor of heat and since the source of light is at a distance from the point

An illuminated Curvlite abdominal retractor showing light concentrate at ground end.

of emission, the light remains "cold," however long the instrument is in use. In addition to many other reasons, an ordinary electric light bulb cannot be introduced into the body because of the heat evolved and the danger of explosion from ether fumes.

2. There is no glare reflected back into the eye.

3. Because of the excellent electrical insulating properties of methyl methacrylate resin, there is no danger of electrical shock to the patient, and diathermy may be applied with the Curvlite instrument in situ.

4. The combination of light and instrument is unique in making surgical work completely independent of normal exterior sources of light capable of being destroyed or accidentally cut off.

5. Since the instrument can be made in curved form and in very complicated shapes, the illumination of deep-lying structures within the body, at the exact point where light is needed, is simple.

Sterilization by Boiling

There has always been a resistance to the use of most plastic materials in surgical work because of the inability to sterilize instruments made of them by boiling. This refers not only to thermoplastic resins, but also to those of the thermosetting type. It is well known, of course, that methyl methacrylate resins normally soften in boiling water or when heated in an oven at about 90 degrees to 100 degrees C.

This disadvantage was a very serious one so far as surgery is concerned, for whilst cold sterilization is reasonably good enough for small instruments used for diagnostic purposes only, it is absolutely necessary that instruments used for any type of surgery must be capable of being either boiled or autoclaved.

A great step in the development of methyl methacrylate resin instruments has, therefore, been made in the announcement by Vann Bros. that the instruments now made by them can be sterilized by boiling, and that prolonged boiling has no effect on the plastic.

Another point is the great strength of the material. We have, of course, always regarded methyl methacrylate as non-brittle. But we should not, just the same, care to fling valuable Perspex surgical instruments about without fearing the consequences. However, one of the directors of Vann Bros. appeared very confident about the matter, and with considerable force flung an expensive abdominal retractor on the ground without any detrimental effect. This strength may be due to the fact that the Perspex instrument is not formed, that is bent from straight rod or sheet, but is cut in curved shapes. The absence of any bending operation thus avoids the introduction of internal stresses.

In addition to the improvements in the raw material, there is little doubt that great advances have been made in the actual fabrication of the instruments. Thus if we examine the surgical diagnostic instruments made of methyl methacrylate resins of only two years ago, it is very apparent that the intensity of light transmitted at a desired point, while fairly high, bears little comparison with the enormously increased intensity obtained to-day. Furthermore, in the older type light escaped at undesirable points.

Perhaps one of the greatest advances has been found in the combination of Curvlite and metal, an example of which is shown in the Brewer's vaginal speculum, shown below. Here metal and Curvlite have been combined, giving the maximum light and the same requisite strength, and at the same time the whole instrument can be boiled for any period.

Within certain limits it is now possible to say that so far as surgical instruments are concerned, "cold light" can be obtained in any part of the body.

Quite apart from the field of surgery, it should be pointed out that this plastic is capable of being adapted for other purposes where "cold light" is a necessity. Doubtless we shall soon see a variety of important applications in industry with the spread of knowledge.

We beg to thank Vann Bros., Ltd., for our reception at their works, and more especially Mr. Rapaport, of that company, for his exposition of the new instruments. He has personally been engaged on experiments with "cold light" for many years here and in the U.S.A.

(Left) Brewer's vaginal speculum fitted with Curvlite unit. Note the simple light attachment.

(Right) The same with the resin illuminated from below.

BUILDING PLASTICS

A New Industry is Born

By T. WARNETT KENNEDY, Dip.Arch. (Glas.),

of Building Plastics Research Corporation, Ltd.

The author, a noted Scottish architect, continues his series on this subject and sets forth the problems that face both the builder and the plastics industry. These notes form both a guide and warning for our future industry.

THERE may be a tendency on the part of building technicians to look upon the use of plastics in building as merely the introduction of another patented system of construction. If this were the case, the all-plastics house would be in danger of suffering a similar fate to the "steel house" turned out by Lord Weir after the last war. It stands in danger of being looked upon as an intriguing novelty, an exotic form forced into bloom under special hot-house conditions. An equally misleading attitude of mind may be that of the plastics manufacturer who believes that the introduction by him of a few proprietary materials into the building market will herald the new age of plastics building. A new material thrown on to the market in this casual way would more than likely have a short career. This procedure presupposes that it is the architect's headache to work out the methods of application of the new materials and in theory the assumption is correct. In actual practice, however, the average modern architect has been bombarded with new materials to such an extent that, after his actual job of planning and design has been done, he becomes little more than a skilled interpreter of catalogues and the manufacturer who has taken the trouble to work out in careful detail the standard methods of application of his material has the best chance of getting his material specified.

New Building Techniques and Plastics

These considerations lead the plastics manufacturer to the conclusion that the capture of really big markets such as are provided by the building or aircraft industries means that to an increasing extent he must study their special requirements. Indeed, these worthwhile markets become in time so specialized that they tend to create new hybrid industries. A recent development has been the setting up by the de Havilland Co. of a plastics section in their new factory, and if Ford's plastic car goes into full production one can anticipate a similar development in the motor industry. With the full development of industrialized methods of prefabricated house-building, building plastics will become a clearly defined and highly skilled occupation correlating the complex requirements of building, as analysed by the research architect, with the astonishingly wide range of new synthetic materials brought to light by the plastics industry.

The point of these speculations is to emphasize that building plastics may be viewed as a significant movement indicating the emergence of a new revolutionary technique of building and to view it as anything less is to damn it with faint praise. This broad view implies vast changes, and a formidable amount of preparatory groundwork remains to be carried out before plastics can be intelligibly incorporated into the body of building knowledge. This groundwork will include the writing of new British standard specifications, the evolution of special methods of test by the Department of Scientific and Industrial Research, Building Research Station, the provision of basic technical data for the guidance of local authorities who are called upon to safeguard the public by criticizing and approving plans and projects submitted by engineers and architects and the writing of textbooks for the guidance of designers.

Under normal "laissez faire" conditions this work would be carried out over a long period by a process of gradual evolution, but if the post-war planning activities at present being carried out under the control and supervision of the Rt. Hon. Arthur Greenwood mean anything, one can assume that this new industry will be fathered and controlled from its birth by a Government department. The entire movement has been brought into being by an unparalleled building crisis, the effects of which will be felt over an entire generation. If the problems have to be solved "in our time" they must be fitted into the framework of a strict national plan rather than that they be abandoned to the rough and tumble of competing commercial interests. One recalls with horror the totally unscientific methods which were adopted after the last war when the nation was delivered up to the mercies of the "spec" builder, whose abortions spread over the face of our country like a rash, blotting out the countryside and reducing our towns and cities to a planless chaos.

The Need for Standard Specifications

The preparation of British standard specifications is, perhaps, the most valuable step which can be taken to safeguard both the public and the new industry. The difficulties, however, are obvious. Plastics are subject to such a wide field of variation and there are so many purpose-made compounds that anomalies are frequent. Existing British standard specifications are aimed to control the quality more of electrical insulation plastics than of plastics directly suitable for building. The tendency is for the plastics manufacturer to issue his own specifications, but it is hardly likely that competent authorities would accept a similar position when building plastics are under consideration. Perhaps the first building plastics specifications will be for reinforced thermosetting compounds used as structural elements in prefabricated or light-framed structures. While the phenolic range is already covered by a fair number of specifications, the mechanical strengths are not adequately worked out. It is not suggested that phenolics are necessarily the most important plastics to the architect, but the structural frame of a building would be the first element upon which rigid Government control would be vitally essential.

In a previous article I suggested that the "raison

d'être " of plastics in post-war building would be largely on account of their suitability as a medium to attain the new ideals of complete prefabrication. This implies assembly line methods of house manufacture. One can forecast, therefore, the setting up of new highly industrialized types of building construction companies whose special functions will be to collect from the plastics industry the individual plastics components and to prefabricate large sections of building structures. These companies will employ skilful assemblers not only for work in the factory, but for erection work on the building site. Architects and designers will be presented with the opportunity of composing, from an almost unlimited range of standardized parts, any type of plan to meet individual requirements. Flexibility of design can thus be correlated with the economic advantages of standardization. These objectives have hitherto been unrealized and so great has been the frustration of designers that many still believe that standardization of methods is synonymous with monotony of design. It is an anomalous fact that the methods and materials of the building industry to-day have largely created a monotonous and soulless suburban environment.

Building fabrication companies will do more to isolate and define this new industry than any other activity. They will serve as a focal point towards which the work of building plastics technicians will be directed. It is necessary that the new industry be a unity in itself. If it be allowed to develop merely as an appendage to either the plastics or building industries it stands as much chance of commanding public attention as do questions on Scottish affairs in Parliament. To many, it may seem premature to indulge in these speculations, but surely we have learned since 1918 that although the war be won the peace is not necessarily assured without accurate foresight.

The Purification of Water —by Synthetic Resins

LISTENING to the Brains Trust on Sunday afternoons is always one of the most instructive and amusing of our pastimes.

We are, of course, being " scientifically inclined," always pro Dr. Julian Huxley right or wrong and often anti Professor Joad wrong or right. Commander Campbell stands in a neutral position, always pleasing to listen to because of his cheeriness and practical sense.

On Sunday, October 26, however, the Commander made mention of a method of producing drinking water by dropping a tablet or pill into sea water, the tablet precipitating all the salt, and thus producing a drinkable water. He said that the apparatus had not yet been perfected, and that the National Physical Laboratory at Teddington was interested. The matter is somewhat puzzling to us, for if it were a matter of mere precipitation, then simple filtration is all that would be necessary and the greatest boon to shipping would have arrived. Lifeboats could be fitted with a simple filter. Off-hand, we cannot imagine how sodium salts can be rendered completely insoluble by simple means, or even removed by an absorption process equivalent, say, to the activated carbon process. However, if potable water has been produced by such a method, someone has made a stupendous discovery.

In the face of insufficient information, however, it makes us wonder whether Commander Campbell has not got hold of the wrong end of the stick and is not thinking of the application of synthetic resins for water purification which was worked out by the Chemical Laboratories at Teddington and which we mentioned over four years ago in this journal.

Making Soft Water

The need for making drinking water on board ship has worried navigators since ships first sailed long distances from land, and we suppose Columbus carried large stores of it in barrels, and no doubt it turned brackish and undrinkable. Distillation plants making potable water on board ship were probably not introduced until late in the 19th century.

In industry there is a far wider use of " good " water, although not necessarily pure water. It is absence of hardness that is required, absence of those salts which cause scale in boilers, waste soap, injure textiles, etc. Thus, soft water must be produced for use in all steam-raising plants, in laundries, in artificial silk works and a hundred other industries.

The early history of pure and soft water manufacture concerns distillation, which is costly and is almost only used in fine chemical manufacture, or the well-known lime-soda processes, which are now considered cumbersome and comparatively inefficient and were used for boiler work. About 25 years ago the zeolite processes were introduced whereby hard water is passed through certain natural or artificial silicates (base exchange materials), whereby the calcium salts producing hardness are eliminated. They are replaced in the water by other salts, soluble, it is true, and therefore non-scaling, but still remaining in the water.

Yet another process was the treatment of certain " carbonaceous " materials, such as peat, coal, lignite, wood, etc., with fuming sulphuric acid, chlorosulphuric acid, etc., producing compounds which were capable of ion exchange. Such materials contain less silica than the siliceous zeolites, and hence were better suited to withstand the action of acids, and may be converted to their hydrogen derivative. Metal ions may be removed from an aqueous medium and replaced with hydrogen ions, whereby the salts are converted to the corresponding acids. The total dissolved solids, and hardness, were thereby reduced. The carbonates and bicarbonates could be removed by conversion to carbonic acid, which was eliminated by simple aeration. The water treated with a hydrogen exchanger was blended with raw water, or with water treated with a sodium ion exchanger, to reduce the acid content of the water, lower the total solids, and effect a removal or reduction in hardness.

Ion Exchange Resins

A great advance in water purification was made in 1935 by two chemists, Holmes and Adams, working at the Government Chemical Laboratory at Teddington.

They discovered that certain resins were able to remove the positive and negative ions of salts soluble in water.

An explanation of the word " ion " may be necessary here:—A salt is a compound formed by the union of a metal and an acid. When it dissolves in water it is presumed to split into two ions, the metallic or cation ion (with a positive electrical charge on it), and the acid ion, or anion (with a negative electrical charge). This does not mean that the true solid metal wanders free as such. The metallic ion with its positive charge has changed its character and is never quite free from the anion with which it is continually recombining and separating.

Thus, common salt, which is composed of sodium and chlorine, breaks up into a sodium ion (with a positive charge), and a chlorine ion with a negative charge. That they are not bound as strongly in solution as they are in the solid form is shown in the ease with which chlorine is given off and sodium (in the form of caustic soda) is made when a current of electricity is passed through brine.

The work of Adams and Holmes showed that, by using two different types of synthetic resin, one type removed the positive ion (or cation) and could replace it with another, while the second type of resin removed the negative ion (or anion).

Let us first consider the exchange or the removal of the salt calcium sulphate, always present in ordinary tap water and one of the scale producers in boilers.

(1) Cation Exchange Resin.

(a) The calcium ion can be exchanged for the soluble sodium ion which does not " scale," by the use of a sodium salt of a special resin. The water containing calcium sulphate is passed through a bed of this resin and the following exchange takes place:—

Cation Resin (Sodium type) + Calcium Sulphate = Calcium Resin + Sodium Sulphate.

The " calcium resin " remains in the bed and the water containing the sodium sulphate passes out of the apparatus to the boiler suitably softened, since sodium sulphate is so soluble that it does not form a scale. From the above it will be seen that if a soft water only is required and that the complete removal of salt, that is a water equivalent to distilled water, is not necessary, then only one resin is needed.

If, however, a water free from all salts is necessary, then two beds are required.

(2) Cation Exchange Resin and Anion Exchange Resin.

(a) First, the water is passed through a cation-removing resin, not a sodium type, but a hydrogen type. Thus:—

Cation Resin (Hydrogen type) + Calcium Sulphate = Calcium Resin and Sulphuric Acid.

It will be noted here that the calcium ion is replaced by a hydrogen ion instead of sodium in the previous case, giving sulphuric acid. As before, the calcium ion has joined on to the resin bed.

(b) The water containing sulphuric acid is then passed through a second bed, an anion-removing resin.

Anion Resin + Sulphuric Acid = (Anion Resin-Sulphuric Acid) combination.

The combination remains in the resin bed and the exit water is completely free from contained salts.

It is quite commercially feasible to produce, by this means, water as good as distilled water, and, in fact, units have been installed with great success, but there is obviously a limit to the concentration of contained salt which can be removed.

This treatment is generally possible with waters which contain less than 500 parts per million, so that the removal of salt from sea water which contains some 35,000 parts per million is at present out of the question by this process.

Ion exchange resins have, however, enormous scope in industry, and the Resinous Products and Chemical Co., of Philadelphia, Pa., who are licensed manufacturers in the U.S.A. of the resins under the name of Amberlites, have given us much useful information regarding their use and applications.

In passing, it should be noted that regeneration of the exhausted resins is carried out quite simply.

Industrial Applications

(1) Softening Water, i.e., the removal of simple hardness-producing elements, such as calcium and magnesium ions, for laundries, hospitals, domestic units, canneries, chemical manufacturers, pigment manufacturers, textile mills, dye works, breweries, power plants, hotels, restaurants, ice plants, railroads, steamships. Since, in applications of this type, only the hardness of the water is objectionable, the cation-removing resin can be used in the form of its sodium salt. However, for use in laundries, home units, ice plants, hotels and the like, it is also desirable to remove such stain-producing impurities as iron and manganese, in addition to the hardness-producing salts. The resin is, therefore, doubly suited to such applications, since it removes these objectionable cations, as well as calcium and magnesium ions.

(2) Reduction of Bicarbonate Alkalinity.—Beverage plants, ice plants, powerhouses, railroads, steamships, municipal supplies.

This reduction is brought about by " split-stream " treatment, which may be effected by two methods:—

(a) By blending of water treated with hydrogen exchanger with raw water.

(b) By blending of water treated with hydrogen exchanger with water which has been treated with a sodium exchanger.

Alkalinity in ice manufacture results in " snowy " ice, and excess alkalinity in boiler-feed water contributes to the embrittlement of exposed boiler parts.

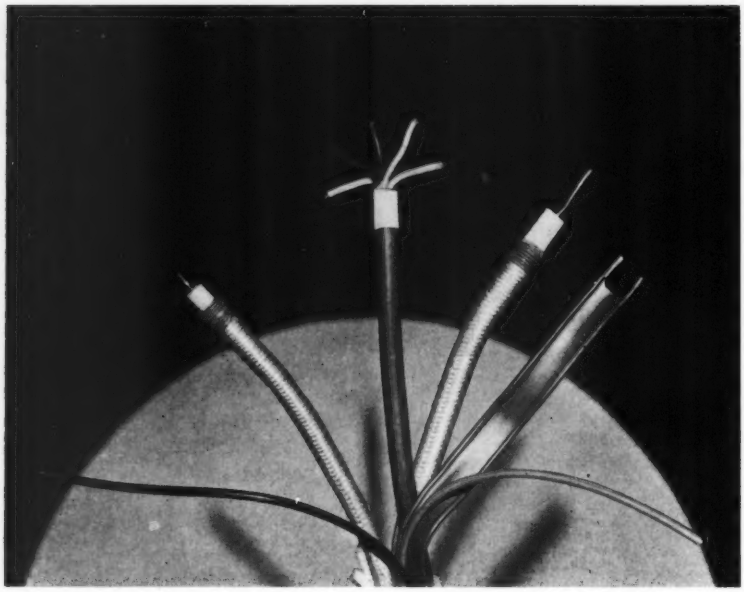
(3) Reduction of Total Solids in Water.—High-pressure steam generation, beverage manufacture, textile processing, ice manufacture, etc. A large amount of mineral matter in ice causes uneven freezing, and a high concentration of solids in high-pressure boiler-feed water causes increased hazards of scale formation and necessitates excessive blowdowns. Resinous exchangers also offer an excellent method of removing ammonium ion. The results obtained with installations of combined cation and anion exchangers compare favourably with those previously obtainable only by distillation.

(4) Removal of Iron, Copper and Other Harmful Cations.—Textile mills, dye works, tanneries, food industries, paper mills, ceramic manufacture, chemical manufacture, pigment manufacture, resin manufacture, pharmaceutical manufacture.

(5) Recovery of Valuable Elements from Aqueous Solutions.—Copper from rayon mill wastes; cobalt manganese, nickel from mine waters; gold and cyanide from industrial wastes.

It will be seen from the foregoing notes that the applications of these new synthetic resins are very numerous and provide for industry a new tool which older processes for the treatment of industrial waters could not hope to emulate.

Plastic Insulating Sleevings



A variety of sleevings and sheathings extruded from polyvinyl chloride and cellulose acetate.

By W. CORNEHLI

The author discusses the place of extruded cellulose-acetate sleevings in that field of electricity which has almost become the prerogative of polymeric plastics

FOR many years insulating sleevings have been known and widely used in the electrical industries as insulating materials for covering bare conductors. The first known type of insulating sleeving, which is still produced to-day in large quantities, is that braided from cotton or silk yarn, treated with a solution of linseed oil varnish and dried in an oven at a temperature of about 100 degrees C. This coating process is repeated a sufficient number of times to give a smooth and flexible coating of the required thickness. The dielectric strength of these sleevings is 300-500 volts per mil., and they fairly well fulfil the requirements for a cheap insulation, with the one exception that they are not suitable for use under tropical conditions. In humid atmospheres the varnish coatings peel off, and the fabric base absorbs moisture to the detriment of its electrical properties; moreover, the sleeving is not proof against white ants, etc.

The Progress of Plastic Sleevings

About eight years ago, in her drive to substitute imported raw materials by home-produced products, Germany started experiments to replace the cotton braided material. At first sleevings of artificial silk were treated with oil varnishes and later nitro-cellulose lacquers, the latter process giving an extremely flexible sleeving. Meanwhile the development of vinyl chloride and vinyl acetate plastics led to a series of experiments, which resulted in the production of plastic sleevings by an extrusion process without any fabric base. Such thermoplastic sleevings were imported in fairly large quantities into this country, and later British firms started to manufacture these sleevings from raw materials imported from Germany, Canada and U.S.A.

With regard to the resistance against absorption of moisture from the atmosphere, the plastic sleevings proved to be excellent and were, therefore, very suitable for use under tropical conditions. Other advantages are that they are physically and chemically stable and do not crack or age. They are not inflammable in the sense that they do not support combustion, especially when tested with a conductor inside. The dielectric strength of these sleevings is eight to ten times that of an oil-varnished sleeving with fabric base, and they are produced in continuous lengths, whereas the latter, especially in the larger bores, are only produced in lengths of 1 yd. or 1½ yds. Lastly, all standard colours can be supplied in a wide range of different shades. For all these reasons the plastic sleevings very soon found a big market in the electrical industry for telephone and wireless apparatus, relays, meters, time switches, instruments, etc.

Advantages and Disadvantages of Polymeric Type

In spite, however, of their apparent advantages over fabric oil-varnished sleevings the plastic sleevings suffered from one great drawback, namely, that owing to their manufacture from thermoplastic materials they have a low heat resistance of 70-80 degrees C. Plastic sleevings do not, therefore, stand up to the heat when transformer coils or armature windings are treated with impregnating compounds. Further, all plastic compounds are characterized by a bad thermal conductivity, and this leads to a "heat drift" effect; that is, the heat from, say, a soldering iron passes along the conductor which is threaded inside the sleeving and softens the plastic, and in the case of sharp bends the wire breaks through the sleeving and destroys the insulation. To overcome this difficulty several methods are available, such as using a conductor insulated with a layer of paper or cotton to avoid direct contact between the copper and the sleeving. Alternatively, the design of the wiring can be so arranged that there is at least 2 ins. between the tag and the first bend of the wire. The use of a flat-pointed soldering iron with high ohmic resistance and multicore solder helps to reduce the working temperature and facilitates a speedy joint.

Generally speaking, for low-tension work plastic

sleevings are satisfactory and reliable, but for high-tension work the requirements of industry have led to the development of a so-called reinforced sleeving, which is now produced by sleeving manufacturers in two different types. In the first type the plastic sleeving is braided on the outside and cemented on, but the better solution to the problem is a high silk sleeving to which the plastic is applied on the outside. In both these types the mechanical properties are greatly improved, in particular the tensile strength increasing up to 3 tons per square inch. So far as the heat drift effect is concerned, the sleeving with the plastic on the outside offers greater advantages, as the silk lining insulates the plastic from the hot copper conductor. Incidentally, silk is regarded as the best fibrous material for heat insulation, and this, together with the electrical properties, means that the silk and plastic sleeving is a very efficient insulation with a promising future.

New Cellulose Acetate Types

Polyvinyl chloride sleevings are manufactured in this country under various trade names, and up to a short time ago the raw materials were imported, but they are now being produced in fairly large quantities in this country. Another thermoplastic sleeving, manufactured from British-made raw materials, has in recent years been introduced into the market. This sleeving is made by extrusion of cellulose acetate, one of the oldest-known plastic materials. Cellulose acetate was being produced on a commercial scale during the years 1895-1900, and developed rapidly during the last war owing to its being widely used in aircraft dopes. The toughness of the material and the economical manufacturing process of injection moulding or extrusion kept cellulose acetate plastics in the forefront of plastic materials in spite of competition from the many new thermoplastic and thermosetting materials which have been put on the market in the past 15 years.

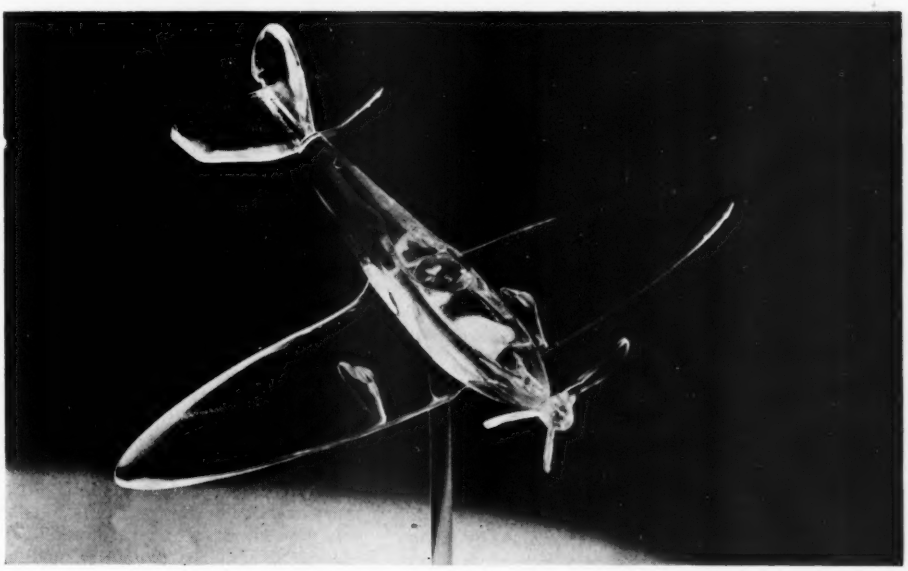
The flexibility of polyvinyl chloride sleevings depends on the grade of polymerization, a soft and rubberlike plastic being produced by low polymerization, whereas the flexibility of cellulose acetate is determined by the content of plasticizing agents. By varying the amount and type of plasticizers the properties of the cellulose acetate can be varied, and by this means it has been possible to produce a plastic suitable for the extrusion of sleevings. In general, these sleevings are not as flexible as those made from polyvinyl chloride, but are supplied with a flexibility of the same order as that of copper wire, so that with a wire threaded through the sleeving both wire and sleeving would break at approximately the same time when bent through an angle of 360 degrees a number of times. In other respects there is very little difference to be found between the two types of sleevings, although, of course, cellulose acetate is cheaper.

Electrically, the cellulose acetate sleevings have a breakdown value of 6,000-8,000 volts; they are free from arc tracking and do not deteriorate when ageing and under tropical conditions. They soften at about 75 degrees C.

In the same way as polyvinyl chloride sleevings the cellulose acetate sleevings comply with the general specifications of the Post Office, Admiralty, Air Ministry, etc. The usual wall thickness is .015 in. to .020 in., but for special requirements this can be increased to .040 in.

The Testing of Sleevings

Several methods of testing sleevings have been developed by the authorities and incorporated in their specifications. These tests relate to limits for bore and outside diameter, bending and flexibility (usually done by bending the sleeving with an inserted wire over a mandrel of several times the diameter of the wire), resistance to tropical conditions, etc. In the tropical test the dielectric properties are measured after 100 hours in exhaust steam at 75 degrees C. The electrical tests include breakdown at 50,000 and 100,000 cycles per second and surface resistance. A standardization of the existing specifications in the form of a B.S.S. would be of great assistance to the manufacturers producing a sleeving which would fulfil all the requirements of the electrical industry. The majority of present-day specifications being very stringent, means that sleeving of a very high quality must be produced, and plastic sleevings have provided the answer to many insulation problems in modern electrical apparatus.



"I see Man, the artificer, soaring to heights undreamed of . . ."

A. De la Roche (1720-1785).

A MODEL IN PERSPEX

With grateful acknowledgments to I.C.I. (Plastics), Ltd.

World's Industry

GENERAL ENGINEERING

Refrigerator parts in thermosetting and thermoplastic materials have been discussed in previous issues of this journal. Plastics department of the Du Pont Co. now state that in a current refrigerator 39 parts are actually in plastics, whilst, altogether, there are 77 possible applications. On one model the evaporator frame has an area of 204 sq. ins., the total weight of plastics used in the whole machine being some 10 lb. **Porous metal castings** are frequently rejected in spite of the fact that, for many types of service, even under arduous conditions, they could be successfully reclaimed by a sealing process. One such process, applicable to a wide variety of ferrous and non-ferrous metals, involves the injection, under pressures up to as much as 500 lb. per in., of a special solution of Bakelite. After release of pressure and draining off excess of fluid, the viscosity of which may be selected to suit the porosity to be dealt with, the job is subjected to curing within the usual temperature ranges for a suitable time. It is interesting to note that practical tests have shown that for many types of porosity a job may be proofed against seepage up to bursting pressure, whilst no breakdown of the " filling " occurs under normal vibration or repeated impact. This system of recovering is to be commended for many components operating up to moderate pressures at room temperature. It may be used for marine components, the cost of which should negative the needless rejection of large and difficult castings for minor mechanical unimportant porosity. It is safer and more rapid and simpler than sealing in hot oil or gum solutions. **Stability of structural materials** when exposed to weathering is a prime requisite in almost every phase of engineering. Research by Nitsche and Salewski (Materialprufungsamt, Berlin-Dahlem) covered effect of exposure for periods of 6, 12 and 24 months on phenolics with mineral, asbestos and woodflour fillers, and on a urea resin. Bending strength, impact strength, water absorption and alterations in length of test pieces, were determined. Bending strength and impact strength were, in general, found to decrease with exposure, although the latter property was not affected in all types of resins. Water absorption varied and could be determined from the known results of short-time tests; in the case of plastics quoted, variations could be ascribed largely to structural differences caused by varied properties in the filling materials. Especial significance was attached to dimensional alterations (determined as alterations in length) caused by swelling, the effect of which may be more or less serious in practice, according to the form and mass of the component concerned, and because of the load capacity for plastic deformation of the materials, this resulting in the possible production of dangerously high stresses. The last point noted obviously points to the need for special care in the design of plastic parts called on to withstand prolonged weathering, the variable nature of which, in itself, may constitute a source of trouble—alternate wetting and drying, for example.

ELECTRICAL

Cashew-nut-shell liquid exports from Brazil to U.S.A. have assumed proportions sufficient to attract most lively interest on the part of the Brazilian Government. The so-called " oil " is of a phenol nature and is being employed as the basis of numerous synthetic resins, including cold-setting phenol-aldehyde cement for cable-sealing, heat-hardening insulating varnishes. The electrical properties of resins prepared from this material are outstanding in quality. **Fluorescent strip lighting,** although much nearer to " daylight " in colour than the light yielded by filament lamps, is different in the red. By slipping over the tubes coils of suitably coloured Tenite, the necessary correction can be made; alternate clear and red strips have been found most successful. For those who, like ourselves, may miss, in the fluorescent strip light, the yellow tint given by filament lamps, it is suggested that a similar device could be adapted to give the requisite over-correction at the end of the spectrum. **American battleships,** which may shortly be fighting, and British battleships, which have already been doing so for the past two years, are taking advantage of shatterproof lampshades moulded in white or coloured translucent plastic. Among the materials used in the American Navy are Plaskon, moulded by the plastics division of the G.E.C. It may be noted that among the properties demanded of material for this purpose is ability to withstand deterioration by ageing under the influence of heat and light.

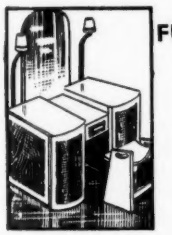
BUILDING

Floor outlet for vacuum-cleaning installation, formerly produced as an assembly of four brass castings, has been redesigned by G. Rohde. New form consists of a zinc-base die-casting made in three parts, over which is moulded an attractive case of Tenite. This work was carried out by the American Insulator Corp. for the Fibre Conduit Co., New York. Unlike the brass casting, the zinc foundation casting does not need polishing before being plastic covered. **Concrete road surfaces tend to scale** under heavy impact loading imposed by fast traffic. According to Hercules Powder Co., this may be diminished or eliminated by incorporating in the original cement (during grinding of the clinker) small amounts of a natural resin. Quantities up to 0.05 per cent. are suggested. There would appear to be an opportunity for the exploitation of certain synthetic resins in this connection. No explanation of the mechanism of the treatment has been advanced.

TEXTILES

Fire resistance is imparted to textiles by treatment with chlorinated organic compounds, amongst which are chlorinated rubber or polyvinyl chloride, compounded with inorganic or zinc borate, solvent, plasticizer and pigment. The theory of their action is, according to the "Laundry Record" (U.S.A.), that, on heating above decomposition point, hydrochloric acid is evolved, this functioning as a "blanketing" agent and cutting-off oxygen. The metallic borates appear to prevent premature decomposition, whilst the pigment stabilizes the chlorine compound against light. Compositions for practical use are stated to contain one-third by weight of chlorinated material (with solvent), the balance consisting of a suitable mixture of the other ingredients. Alternatively, 20 per cent. of a solution of polyvinyl chloride is compounded with 15-20 per cent. metallic borates, with the balance of plasticized pigment, etc. Treatment also prevents attack by moulds.

tr Employs Plastics



FURNITURE

Adhesives based on casein are treated at length in a recent issue of "Vernici" (Vol. 15, p. 101 et seq. to p. 601). Numerous formulæ are given for mixtures to suit different conditions, and reference is made to the incorporation of vegetable oils into certain adhesives, although it is stated that such mixtures are of doubtful utility. **Polish for furniture** is covered by Hungarian patent 126,804. Applicable by brush, bathing and spray, the polishes are based on condensation products of aromatic amines and aliphatic aldehydes. Examination of the patent reveals nothing strikingly original in the composition or use of this mixture.

CHEMICAL

Modern routine laboratories have established themselves widely as integral parts of almost every industry. Laboratory organization has tended, more and more, to become embodied as a definite part of the industry, and not as an isolated unit separated from the remainder of the business. For this reason, laboratory designs have become specialized in many industries in order that their efficiency level may be at a maximum. In the equipment of the modern laboratory plastics already enter largely. Benches, racks, furniture, lighting fittings, equipment for handling acid, and many parts of precision instruments have become accepted avenues for the exploitation of synthetic resins. More recently increased interest has been taken in certain of the newer types, particularly the colourless transparent varieties. A small chemical laboratory was instituted in which all the fume cupboards, other than those directly exposed to strongly heated steam or air, were fitted with bent Perspex sheet in place of glass, the customary wooden framework being virtually eliminated. As a result, it has been found that ease of working has been greatly facilitated due to better lighting. A further novelty of this laboratory consists in the provision of bent Perspex shields around the balances in the balance-room, by means of which, with the aid of strip lighting, very efficient illumination is attained, shadow effects are entirely absent, and, by dispensing with the aid of powerful lamps at short working distance, unpleasant heating effects have been eliminated. It is proposed at an early date further to extend the use of these materials. Two main directions are visualized—increased use in purely constructional and constructional-decorative work, and, on the other hand, increased use in apparatus. On the former side thermal-insulating anti-glare plastic tiles are to be applied to the walls, and modern daylight illumination incorporating coloured plastics for achromatic correction will be used. In order to overcome some difficulties experienced in cleaning and maintaining the good appearance of the rubber floor covering, it is hoped that some suitable plastic material will be obtainable in this country when required. In connection with the use of plastics in technical apparatus, one interesting use has been suggested, viz., that the salt spray set-up be constructed entirely of synthetic resins, preferably of the colourless, transparent, chemically resistant type. The use of metal in this connection has never proved satisfactory, as the salt solution used is strongly corrosive. Stainless steel withstands its action fairly well, but is expensive and difficult to work. Copper and copper alloys are quite unsuitable, as their use leads to the deposition of copper on the specimens, with the consequently indeterminable acceleration of corrosion effects. Plastics, however, are free from all these objections. In putting forward these proposals stress has been laid on the fact that those applications contemplated and those already put into practice are done so designedly with the object of utilizing the specialized properties of these materials.

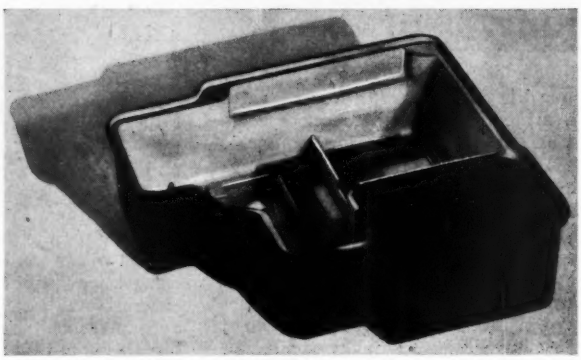
MISCELLANEOUS

Economics and production of synthetic rubbers are discussed in "Vernici," 1940/16/199. The account is primarily concerned with emphasizing the strong competition accorded to the natural material by its synthetic rivals, this in spite of high production costs, namely, 3 R.M. per kilo for Buna, and a selling price of 65 cents per lb. in U.S.A. for neoprene. Sources of raw materials for various types of synthetic are discussed, production costs being stressed. **Production of Caffelite** is summarized in a recent issue of "News Edition" (Am. Chem. Soc.). The coffee beans are comminuted, the meal obtained being treated with solvents for removal of oils and caffeine. These are separated, the balance of the solvent extract being returned to the oil-free meal. Water and, as a rule, an acid catalyst are next added to the meal, which is autoclaved at approximately 150 degrees C., washed, neutralized and dried in vacuo. The product is a thermosetting powder known under the name Caffelite, which is worked up in the usual way. A pilot production plant handling 1,000 lb. of coffee per hour is in course of construction in Sao Paulo. **Protective apron,** proof against acids, oils and greases, and resistant to inflaming dry heat, has been placed on the market by the American Optical Co., Southbridge, Mass. It is specifically stated not to be made of synthetic rubbers, oiled duck, or the like, and would appear to be a textile base treated with a resin of the Mipolam type. Its uses would seem to be commended not only in the chemical industries and in many branches of engineering, but especially in those occupations where the oil-dermatitis hazard is high, or may increase as a result of long hours and the pressure of defence work. **Hercules Powder Co.** has now been in control of the synthetic-resin manufacturing of J. D. Lewis Inc., Providence, R.I. It will be recalled that the Hercules Co. is the largest producer of natural rosin in the U.S.A.; its acquisition of the business raised it to the ranks of a major synthetic-resin producing concern at a time when national defence measures call for maximum concentration and co-ordination of raw-material-producing plant. Amongst products to be marketed are the various phenolic and alkyd resins for which the original company was noted. **Chinese industry,** harassed and restricted as it is by Japanese territorial ambitions, is said still to be producing phenolic and cellulose-base plastics in Shanghai. The Sheng-Te weaving factory imports for the purpose phenol, formaldehyde, hexamine and casein. **Lignin, now obtained from woodflour** (in which it is present up to 47 per cent.) is, according to a past issue of "Organ. Khim." (Russia), converted into a valuable plastic by treatment with analine and furfural, together with calcium oxide. Impact strength up to 4.6 kg.cm./cm.^{2} and water absorption (for 24 hours' immersion) as low as 0.8 per cent. are claimed. One mix was shown to be resistant to the action of cold 25 per cent. sulphuric acid.

Coating Plastics with Metal

Discussing the Theory and Practice of Sprayed-metal Coatings on Plastic Bases. Some Indication is given of the Various Fields of Utilization, Particularly in Electrical Engineering, of Such Composite Masses

ABOVE are illustrated two moulded components, that on the left being internally sprayed with zinc. Note awkward corners and cavities, each of which, however, has received a perfect metallic coating. The smaller component to the right is completely sprayed with zinc.



COMPLEX meter casing moulded in phenol-formaldehyde resin and sprayed on interior with a screening coat of metallic zinc. This unit functions in every way equally as well as a metallic casting or pressing and possesses in addition the desirable properties of high-corrosion resistance and pleasing finish.

SINCE the development of the metal-spraying process by Schoop, some 30 years ago, the technique involved has undergone continued improvement, whilst the field of utilization of the method has constantly expanded. Fundamentally, the metal-spraying process may be used for applying to any basic surface, metallic or non-metallic, a coating of metal, which is usually required to be as free as possible from pores and to adhere as strongly as possible to the basis. In effect, therefore, the sprayed article acquires at its surface the properties of a metal, e.g., metallic conductivity for heat and electricity, a great or less resistance to mechanical wear or surface flow, and, particularly if some final finishing process be employed, the colour, lustre and reflectivity of the particular metal which has been applied.

Spraying Facilitates Control

It is important to notice, however, that whilst all these qualities may be obtained it may, in certain cases, be desirable on economic grounds to concentrate on the attainment of one or more requisite qualities, e.g., the production of a high thermal conductivity at the surface of a non-metallic base. In addition, the nature of the spraying process is such that peculiar properties, not as a rule associated with a compact metal, may be obtained, e.g., controlled micro-porosity to facilitate retention of an oil film.

It is proposed in the following account to discuss a more-recent development, sponsored by Plastic Spray, Ltd., for the production of metallic coatings upon the surface of plastics. The process is equally applicable to moulded or cast resins and to laminated materials. The nature of the resin base is immaterial, and a metallic film may be applied with equal readiness to cast phenol-formaldehyde resins and to nitro-cellulose base materials.

The precise nature of the sprayed film has been the subject of desultory investigation for some years, but it can hardly be claimed that any really plausible explanation has been advanced to account for the mutual adhesion of the individual globules which go to make up the film itself. The adhesion of the film, however, to the basis appears, as a rule, in the absence of subsequent heat treatment, to be of a purely mechanical nature. Thus, dead smooth surfaces do not, in general, lead to the production of adherent films, whilst, on the contrary, etched or sand-blasted surfaces provide excellent keys for sprayed metal, which may be built up to almost any thickness.

In this particular instance, the plastic surface is subjected, prior to spraying, to a suitable mechanical refining treatment, after which the metal is sprayed on by means of the Schori metal-spraying pistol, which, as is known, is fed with the metal in the form of a fine powder. Another type of spraying gun is fed with wire. Broadly speaking, it may be understood that any metal, metallic alloy, intermetallic compound and, in some cases, certain heterogeneous metal/non-metal mixtures, capable of production in powder or wire form, may be sprayed from a suitable gun.

It may at this point be noted, incidentally, that the Schori gun is suitable not only for the spraying of metallic films on to non-metals, such as plastics, but with equal facility may be used for spraying plastic materials, such as hard, natural, or synthetic rubbers, or phenol-formaldehyde resins, on to metallic bases.

The Metal-on-plastic Complex

In order fully to realize the properties of a metal-sprayed plastic it is best to visualize the finished work as a compound material, the properties of which may or may not be the arithmetic means of those of its components, either metallic or non-metallic. It is necessary to stress this last point because, whilst a plastic mass coated with a thin layer of metal, as is usually the case, exhibits predominantly the mechanical properties of a

plastic mass, yet, were the metal sprayed on for such a period that its thickness assumed a proportion comparable to that of the plastic itself, then the mechanical properties of the mass might well be very different from those either of a metal or of a plastic.

For instance, the plastic backing would tend to exert a powerful damping effect upon longitudinal vibrations, whilst transverse vibration would also be affected, but probably to a lesser extent. Again, were a heavy metal coating applied to each side of a plastic base, then the impact properties of such a base would be profoundly modified. Even more pronounced changes may be visualized if consideration be given to the combined electrical and mechanical properties of a metal-sprayed plastic base.

Promoting Economy in Metals

Particularly at the present moment, it is desirable that every attempt be made to economize in the use of metal, which, for numerous structural purposes, must be envisaged as indispensable. For many purposes, however, massive metal in the form of fabricated sheet or castings was, and indeed still is, used for purposes which could be served equally well by suitable synthetic resins, provided that these could be given (to the required degree, and at the correct point, or points) certain essential properties possessed only by metals.

Reproduced in this article, for example, are illustrations of two castings of a type normally produced either as metal castings or as stampings from sheet. They are required to possess electro-magnetic screening properties, and for this purpose, of course, a high-conductivity surface must be provided. This is automatically assured by the use of a solid metal which, in addition, possesses requisite mechanical strength, particularly rigidity. However, the items in this instance are, in fact, phenolic-resin mouldings, which are amply rigid enough for the purpose required, and upon which the necessary electric properties have been conferred by a sprayed-on coating of zinc. This system of construction possesses advantages not only for the present period of emergency, but also in the era of post-war development.

To consider first the matter of weight and rigidity; as compared with sheet pressings, the section thickness of the plastic moulding may be increased and the whole system made extremely rigid without increasing weight, as, in most cases, the specific gravity of the resin is less than that of the metals commonly used.

As opposed to castings, it may normally be understood that the plastic moulding is a cheaper mass-production line than the pressure die-casting, whilst, as compared with gravity die-casting or sand-casting, it is more economical with respect to subsequent finishing operations. Indeed, the plastic moulding emerges in the finished form, whilst the sand-casting or gravity die-casting will usually require some degree of surface cleaning, and often some decorative or protective surface treatment, operations which often entail difficulty if the metal surfaces be not perfectly dense.

So far as electrical screening is concerned, the bulk of metal in, say, a massive metal casting performs no very useful function. The currents to be dealt with are usually in the nature of eddy currents or high-frequency currents; the latter particularly, as is well known, tend to concentrate at the surface of a metallic mass, hence, provided the specific resistivity of the metal concerned be sufficiently low, a relatively thin coating is quite as satisfactory, and in some cases, often more satisfactory than a heavier mass of metal.

The use of metal-sprayed plastics, therefore, opens up great possibilities, including the economizing in metal without the sacrifice of desired electrical properties and the reduction of weight.

For straightforward screening purposes, zinc has been found satisfactory. Nevertheless, as implied in a previous paragraph, any metal, for instance, copper, aluminium, brass or tin may be sprayed to achieve some useful physical property and, if necessary, at the same time to obtain decorative or protective effects.

Incidentally, it might be noted that by suitable adjustment of conditions, reasonable flexibility can be obtained in the sprayed coatings. Thus, plastic cable sheathing might be screened very effectually by this technique.

Discussion so far has centred upon the question of replacing massive metal by suitable plastics coated to any desired thickness with a sprayed metal film. Further possibilities exist, however. Due to the flexibility of the process, apparatus may often be so re-designed and constructed that the use of a multiplicity of metal screens may be avoided, a complete unit, for example, being moulded in plastics and subsequently entirely sprayed so that each part be screened from its neighbour; a high degree of compactness being achieved in this way. To facilitate the earthing of sprayed-metal screens, points for the attachment of soldered leads may be provided by a local application of sprayed-on tin. More positive data are provided by a laboratory report now to be summarized.

It was required to determine the screening properties of a sprayed zinc film, and, for the purpose, the usual method of investigating the effect of the screen upon the inductance properties of a coil was employed. Frequencies between 100,000 and 30,000,000 cycles per second were employed, comparative figures being obtained between the sprayed film and tin foil giving approximately the same effects as the sprayed coating.

Unfortunately, the report does not state the thickness of the film used, but concludes from experimental observation that, in essence, it was equivalent in screening effect to tin foil 0.02 mm. in thickness.

As an extension of the application cited here, the possibility may be considered of producing magnetic screens. The object of this move may be considered as twofold. First, for such purposes demanding the maintenance of a magnetically insulated space, the use of a rigid plastic casing sprayed with one of the low hysteresis alloys would be very much more suitable than the use of massive metal.

Sprayed Plastic Diaphragms Suggested

It might, indeed, be suggested that interesting results could be obtained in electrical apparatus for the transmission and reproduction of sound by the use of non-metallic (i.e., plastic or glass) diaphragms sprayed with such low hysteresis alloys. The elastic properties of such non-metallic materials might, it is suggested, commend themselves as in certain respects superior to those of metals for this purpose. Moreover, eddy-current interference effects which may occur when massive-metal diaphragms are used could be eliminated by the use of sprayed metallic coatings of such composition that high resistance obtained between the individual particles composing the coating.

It is, furthermore, postulated that, by the use of this metal/non-metal combination, it should be possible to take advantage of the high mouldability of plastics in order to obtain theoretically ideal contours and to avoid the great difficulty associated with developing such contours in thin metallic sheet.

Ideas—

By the EDITOR

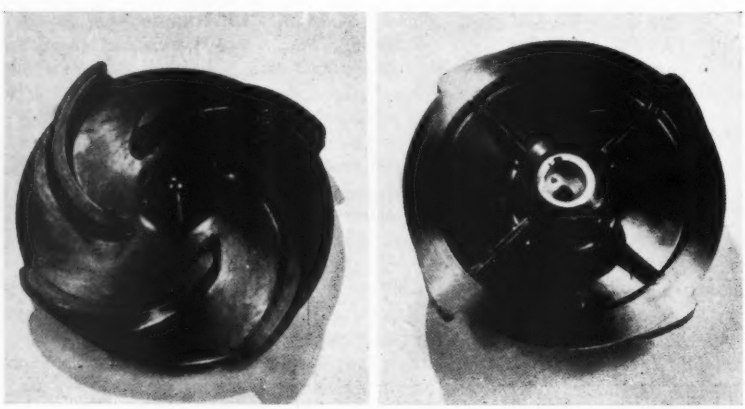
Acid Pump Impeller

Every improvement in the manufacture of pumps carrying acids or acid liquors is welcomed by all chemical engineers. Great interest has been aroused by the development of an acid pump impeller of moulded Durez plastics, by Oliver United Filters, Inc., for Olivite acid-handling pumps. The acid-resistant material, Olivite, from which the pump gets its name, has not only excellent corrosion resistance, but also high tensile strength. With the combination of the Durez plastics and Olivite in the impeller the company tests have shown greater efficiency than with any other material used previously for the impeller. The maximum conditions under which the 2-in. Olivite pump (illustrated) will function in greater efficiency are as follow: 25 h.p. motor heads up to 110 ft., capacity up to 450 gallons per minute.

Development of the moulded Durez impeller necessitated a slight change in design of the impeller itself. This change, however, according to Olivite engineers, while questionable at the outset, definitely proved ultimately advantageous in operating efficiency. The selection of Durez for the impeller was determined by tests which proved the very high acid resistance of a special Durez moulding compound. Plastics being man-made, are subject to physical variation by the manufacturer. This gives them greater versatility than is found in most structural materials—a fact that has only recently been used to its greater advantage by manufacturers.

The impeller without its metal insert weighs approximately 2½ lb. This is a reduction of approximately 75 per cent. from the weight of the impeller in its original material. The one shown is 9 ins. in diameter. A pressure of 330 tons is required for moulding this piece and it is delivered to Oliver United Filters, Inc., completely finished and ready for assembly by the American Moulding Company.

A complete Olivite pump has more than the one impeller part of plastics. This being the very heart of the pump, greatest stress is naturally placed upon it. However, several small but vital parts, such as a lantern ring, a split gland, a resilient sleeve, shaft-sleeve extension, thrower ring, gland yoke, are moulded of acid-resistant Durez. So successful have the applications proved in plastics, still other parts in the drain pipe assembly are being redesigned for plastics.



The Olivite pump impeller moulded of acid-resisting resin.

That Wonderful Lighter

Rarely have we seen a better example of complete bally-hoo than that shown by so many dailies throughout the country over the subject of the plastic lighter. For more than a week it took space on the front page, in importance second only to " Tanks for Russia." We are not decrying the plastic lighter as such, and we presume that some plastic moulders could still take on this work to occupy their presses full time, but since the papers have spoken of a number ranging from one to four million, we wonder if the whole problem has been examined by the Board of Trade. It has probably forgotten that plastics are controlled, that precision machinery is required for its working, and that all plastics should be used for war work. Primarily, we believe that if a little more suitable wood were released, an increased quota of matches is all that is needed. The match-making machinery of the country is not working full blast. If more lighters are wanted, then the amount of metal needed is surprisingly small—a million lighters would absorb under 40 tons of metal, a mere fleabite. If the country wants this metal, there are sufficient railings in two streets in St. John's Wood, where I live, which could be lifted to-morrow. Ever since 1939, the houses in these streets have had notices on their doors: "We have given our railings—won't you." The labels are still there, albeit rather faded. The railings are still there, too. Somebody has forgotten this fine public gesture.

We wonder, too, if the Board of Trade knows that a million lighters consume about 250,000 gallons of petrol per annum. We thought our aeroplanes and tanks needed the stuff.

We have seen one of the plastic lighters and a more wretched design we have never met. It had a tiny loose screw cap to cover the wick, and so would need two hands to work. The cap would, of course, be lost about six times a week.

The " inventor " of the plastic lighter is stated to be a land-girl, but we have seen a good number of examples for many years past, all over Europe.

I don't believe we are what the Germans call a decadent nation, but we are a woolly headed one.

Inquiries and Answers

(In Which is Included General Correspondence)

IMPORTANT NOTICE: If inquirers wish to receive replies by post, a stamped and addressed envelope must be included in their letter. It is understood that the submission of a problem to the Editor permits its publication in this journal.

The Blanking of Perspex Sheet

In your October issue I noted with interest the letter from Pearce and Cutler, Ltd., regarding the cutting of "Perspex."

I am in the rubber industry, but have cut cellulose acetate sheet without spoiling the polish by using cutting blanks covered with a medium-soft rubber quality with a fairly heavy paraffin wax bloom, which allows the blanks to be polished before use and thus avoids any scratching.

Hoping that this suggestion may prove of practical use. S. G. ANDERSON.

Edinburgh.

Cold Setting Glues

You published an article in your October issue under the heading "The Boat Without a Nail," the last paragraph of which (page 204) contained the statement that the phenol-formaldehyde resin glue used in the process described is, so far as you know, the only phenolic resin which is truly cold-setting, all others needing high temperature and pressure to complete the hardening.

We would point out that our subsidiary company, Rockhard Resins, Ltd., now incorporated with Cellomold, Ltd., have manufactured this type of resin on a commercial scale for the past eight years, and these resins have become an increasingly important part of the "Rockite" range marketed by us as their sole distributors.

We have no doubt you will be glad to give the same publicity to this fact as you gave to the statement referred to above. F. A. HUGHES AND CO., LTD.

London, N.W.1.

Metal Powders and Plastics

We have read with interest the article "Plastics and Powder Metallurgy," by H. W. Greenwood, on page 215 of the November issue, and in view of the possible extension of the use of metal powders in connection with plastics, we think that you may be interested to know that we have employed a pseudo-metallic moulding of aluminium powder and phenolic resin which is covered by patent specification No. 519,539 of September 23, 1937.

NORTON GRINDING WHEEL CO., LTD.

Plastics for Model Making

I am interested in an inquiry made by O. Sylvester, of Darwen, under the heading "Plastics for Model Making," in your September issue of "Plastics." If you will kindly forward his address to me I may be able to put his material and process to a very practical use.

I have written to you before, when I explained I am attached to the plastics department of a company. I have direct contact with the principals concerned and believe Mr. Sylvester's process will be of great use.

PLASTICIAN.

Injection Presses Wanted

We shall appreciate it if you can favour us with any information regarding the Daragon injection presses which, we believed, were made in France.

Should, however, you not be in a position to give any details regarding these presses, we should esteem it a favour if you would give us the name of the London firms who acted as their agents.

Westcliff-on-Sea. SPEEDWELL SERVICES.

[EDITOR'S NOTE.—We regret but we do not know the names of the London agents of Daragon presses. Names of British manufacturers of injection moulding machines have been sent to the inquirer.]

Plastics Trade Names

We shall be obliged if you can give us any information concerning the basis and origin of Synthulite plastics.

Queries from time to time arise concerning the composition of plastics and resins marketed under trade names, and this problem refers particularly to plastic material of American origin.

We shall be glad to know if you have any literature tabulating trade names and synonyms of synthetic materials or whether you can recommend any publication which would be of value on this account.

Iping, Sussex. FIREPROOF TANKS, LTD.

[EDITOR'S NOTE.—The only trade name resembling this we can find is "Synthane." This is a laminated form of plastics made by the Synthane Corporation, of Oaks, Penna., U.S.A. Similar products are made in this country by several concerns, the names of which are being sent to you.]

Printing on Plastics

We are looking for a firm which could print plastic laminated sheeting as per enclosed sample and assume that you will be able to recommend us such printers without delay. We would be very grateful for an early reply. P., LTD.

Plastics from Bamboo

Would you kindly inform me as to a possible source of data on a plastic referred to as "Kanex," made from bamboo cane?

PETER E. KYLE,
Massachusetts Institute of Technology.
Cambridge, Mass., U.S.A.

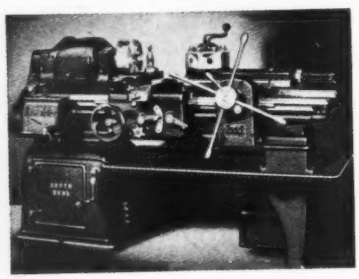
Acetate Sheet Required

Will you please advise us where we can obtain fairly large quantities of white or ivory "Celastoid" or similar material suitable for blanking, for domestic consumption? The size required is .060 in. thick in strips $1\frac{11}{16}$ ins. wide, also the same thickness in strips $2\frac{1}{16}$ ins. wide. NEOSID, LTD.

PRODUCTION NEWS

Raw Materials, New Plant, Works Organization, Control Apparatus, Research, Personal and Trade Notes

A new 16-in. swing turret lathe designed for rapid production on chucking operations and bar work has been announced by the South Bend Lathe Works, Indiana, U.S.A. This lathe has a 16¼-in. swing over the bed ways and saddle wings, 9⅜-in. swing over the tool post saddle cross slide, 1⅜-in. hole through the headstock spindle, and 1-in. capacity through the collet. The ram-type turret has both power feed and hand feed, with automatic indexing and individual stop for each of the six turret faces. A quick-change gearbox pro-



vides 48 changes of turret power feeds, also 48 changes of both the cross and longitudinal feeds for the tool post carriage and a series of 48 screw threads, 4 to 224 per inch. Provision is made for changing the direction and speed of the turret feeds with relation to the carriage feeds. Twelve spindle speeds, ranging from 10 to 731 r.p.m., are available. A two-speed motor permits quick change from high to low speed for reaming and tapping operations. Complete information on this new turret lathe will be supplied on request by the South Bend Lathe Works, Dept. 1P, South Bend, Indiana.

RINDIS FACE-MILLING MACHINE.—We have received from Lorant and Co., Ltd., London, S.E.20, their new publication describing the Rindis Milling and Filing Machine. A new type, F40/12, has been added to the range, with a 12-in. diameter disc. The 10-in. diameter discs are now also supplied with 4-in. cutting surface.

MODERN HAND FIRE-EXTINGUISHERS.—It is well known that many types of hand fire-extinguishers depend upon the basic principle of using carbon dioxide gas, which smothers the fire by displacing the air necessary for combustion.

Two of the general principles used for example are "soda-acid," that is a solution of soda ash into which a bottle of vitriol is broken, and "foam," which is a vast aggregation of small bubbles filled with carbon dioxide gas. In some cases also liquefied carbon dioxide is used, giving a jet of gas, as in electricity stations, for example, with a battery of gas cylinders connected by pipes to the danger points.

The latest scientific principles in this field, however, which have now also been developed in effective fashion to fight both the thermite and the oil incendiary bomb, are well represented by the "R.S.Q." extinguisher, a production of The Nuswift Engineering Co., Ltd., Elland (Yorkshire), in which only water and compressed carbon dioxide gas are employed, the latter being contained in a seamless copper container with a brazed bronze head, fixed inside at the top. On pressing down a knob device a knife edge perforates a small soft copper seal at the top of the container, releasing the compressed carbon dioxide gas, which partly dissolves in the water, and results at once in a high-pressure jet, about 30 ft. in length, discharging through an internal dip tube. The jet also is completely harmless, and therefore can be directed upon human beings, whilst other advantages are that it is intensely cold, because of the

compressed gas, and since there are no salts in solution it is a non-conductor of electricity, and safe up to at least 25,000 volts, so there is no danger of receiving a shock when dealing with electrical equipment.

ENGRAVING MACHINES.—With reference to our note in the October issue, Rudson, Wood and Co., London, N.W., inform us that they have two "Hermes Pat" portable engraving machines for disposal.

MR. HENRY CLAY, Economic Adviser to the Governors of the Bank of England, has been granted temporary leave of absence from the Bank of England in order to take up the post of Economic Adviser to the Board of Trade.

Mr. Clay will be concerned with all the problems (both commercial and industrial) of post-war reconstruction falling to the Board of Trade.

BRITISH PLYWOOD MANUFACTURERS, LTD., London, E.C., and Ponders End, Middlesex, announce that they have accepted the resignation from the above company of Mr. I. M. Edelman, who is leaving to take up other national work.

AROUND THE WORKS

Queen Mary Visits Erinoid, Ltd.

We were delighted to hear that Her Majesty visited the works of this famous plastic concern on October 31. A section of the works Home Guard under Lt. Didcott formed a guard of honour and Mr. Waldron, chairman of directors, and Mr. Dodd, the acting general manager, welcomed Queen Mary when she arrived. Her Majesty saw all the processes of casein and other plastics manufacture and expressed surprise at the enormous number of uses to which these raw materials could be put. Doubtless she was not only impressed with the chemical and mechanical processes involved, but also fascinated by the lovely coloured finished goods this company produces.

De La Rue's and the War Effort

In view of the need for increased production to meet the urgency of the grave war situation the shop stewards of Messrs. De La Rue's approached the management on the question of furthering the productive effort of their factory. As a result a joint meeting of workers and management took place in the works canteen.

Mr. Bridge, managing director, said the present output of the factory was good, but he appealed for every effort to be made until the enemy is beaten.

Mr. J. Clark, secretary of the Shop Stewards' Committee, pressed still further for a greater productive effort from the factory, and called for a resolution "from the floor" to that effect.

The following resolution was moved: "We, the workers of Messrs. De La Rue, pledge ourselves to put our maximum effort into production until Fascism is smashed, and we call upon the Mayor of Walthamstow to appeal to the rest of the workers in the town to follow our lead."

Resinoids and Other Plastics as Film Formers

By B. J. BRAJNIKOFF, Consulting Electrical Engineer

One-time Consulting Engineer to the International General Electric Co., Inc., New York

III.—The Fundamental Tendencies in the Development of Chemical Kinetics

THE preceding survey of the raw material bases for plastics synthesis would be incomplete without reference to its physical aspects.

The creation of new types of organic syntheses based on utilizing gaseous by-products of petroleum treatment or derived from natural and industrial gases gives rise to major problems in the design and construction of appropriate chemical plant.

The dominant feature of most of these new manufactures is that they are founded on the processes of heterogeneous catalysis and require the application of high temperatures and pressures. They are characterized by continuous processes involving complicated mechanized equipment, and in this respect are radically different from old methods of organic syntheses exemplified in the dye industry, with their intermittent operations.

New production needs installations, as typified by the efficient Gyro system, with a great number of compressors for the separation of gases and for the basic technological processes, circulating pumps, low temperature and high pressure reaction columns, heat exchangers and contact apparatus, with numerous auxiliary vessels and fittings, as well as intricate measuring and controlling instruments.

In conformity with the utility of high pressures, as a means of accelerating or carrying out the reactions unrealizable in normal conditions, the modern trend [in the design] is to employ high and super-high pressures, approaching those used by the advanced laboratory technique (3,000 atmospheres and over) for examining processes of polymerization of unsaturated compounds, conversion of gases into acetylene and ethylene and kindred problems.

Another impetus in the development of organic synthesis has been the activation of reactions by applying new and original methods of catalysis.

Parallel with the studies of the mechanism of catalytic synthesis, efforts are being made in elucidating by means of X-rays the dispersion and structure of catalysts of different activity, with the object of finding the methods for increasing their catalytic power.

Arising out of these investigations of the influence of various physical agents on catalysis (e.g., the action of ultra-violet radiations, high frequency fields, etc.), the enhanced catalytic theory has directly effected a bearing on the kinetics of industrial processes.

Boundaries of Modern Kinetics

The second half of the 19th century was a period of the transition of chemical technology from laboratory and tiny factories to the present day gigantic chemical industry.

The same period witnessed the realization on the industrial scale of a great experience accumulated by chemists in the structure of organic combinations and in methods of their synthesis.

The evaluation of the time factor in research is totally different from that of practical technology.

In a laboratory synthesis the essential objects are the uniqueness of results, purity of products, etc. The duration of experiments as well as their costs are secondary considerations. In engineering chemistry, however, time is one of the most vital factors, whose importance attaches not merely to the velocity of a process, but also to its control and complete reproducibility.

It is of interest to note that, whereas in the last century the problems have been mainly riveted to the assessment of yields, i.e., confined to the equilibrium study, the 20th century, and especially the last two decades, are marked by the ascendance of the kinetic theory, that is the questions of velocities and the efficient conduct of complex reactions.

No other method or group of methods applied to investigating the mechanism of reactions is comparable in its possibilities with the kinetic method.

But the study of the above phenomena is not feasible without examining the forces involved in a process, hence the application of kinetics in the study of chemical processes themselves; in this study the laws of the reaction are intimately bound up with the mechanism of interacting forces and their nature, thus leading to the origin and principal features of chemical processes.

The rôle of modern kinetics is best illustrated by the electro-cracking of methane, with the contact time of 0.014 second, giving the maximum yield of acetylene.

Chemistry of High Molecular Compounds

In passing now to a closer study of processes which are of utmost importance to the coating field, a few notes on high polymeric systems will be found helpful. In this respect the physical chemistry of high polymers, with its voluminous record of experimental observations, aided by every device available to research, was able to shed a great deal of light on the basic relations between the macromolecular structure and its size, etc., and, in consequence, on the physical behaviour of the resultant films.

The revealing work of Carothers on the resinous state, Kienle's studies of resinification kinetics, contributions by C. Ellis, Staudinger, and others, have greatly extended the knowledge of high molecular complexes and brought to light factors that govern the mechanism of film formation.

Certain synthetic resins are produced as a result of two fundamental types of polymerization processes

which finally lead to the formation of highly polymerized macromolecules: (a) aggregate products of monomeric molecules, and (b) the process of combination of monomers, which is accompanied by the splitting off of simple molecules (with the release of water, halogen acid, etc.).

The first reaction is defined as the process of polymerization, and the second as condensation polymerization, or polycondensation.

Depending on the structure of constituents used and conditions of reaction, the macromolecules of resulting resinoids may have configurations of either long chains, closed rings, or cross-linked structures.

Very often in the initial phase of the process, as a consequence of certain definite physical factors, at first a linear polymer is formed; this may subsequently undergo transformation into a three-dimensional variety.

For example, in the reaction between glycerine and phthalic anhydride in the first stage of the process, only the more active primary hydroxyls of glycerine take part, promoting thereby the formation of chain polymers, which afterwards turn into three-dimensional molecules by interacting with secondary hydroxyls.

The simplest mechanism of the resinification process consists of interaction between dibasic aliphatic acids and glycols.

According to Carothers,[7] reactions of this class are typical examples of condensation polymerization processes, or polycondensation.

Polyesters obtained by this method are characterized by the possibility of existence in two forms: the normal, with molecular weight up to 4,000-5,000, produced by heating the ingredients under atmospheric pressure, and, secondly, in the form of superpolyesters, with molecular weight 10,000-18,000, prepared in high vacua.

A peculiarity of these superpolyesters, first obtained by Carothers, is the phenomenon of the so-called "cold spinning."[8] It consists in the ability of threads derived from superpolyesters, under tension, to change sharply their internal and external features: the filaments become lustrous and flexible, their mechanical strength is greatly increased, approaching that of ordinary textile fibres—cotton and silk. X-ray investigations show that modifications are the sequel of the parallel orientation of separate chain molecules.

In the three-dimensional polymers of glycerine-phthalate, phenol-aldehyde, and certain other resins there may also exist macromolecules in sphere form.

In the opinion of Ellis, the resin at the initial stage "A" may be regarded as a fluid, whose molecules are relatively small and freely rotating, and where a solvent may penetrate into its structure.

On cooling the resin, under these conditions, the micellar structure is formed due to secondary valence forces.

Under the action of solvent, such a lattice may be subjected to the reversible process of disaggregation—swelling, solvation, colloidal solution—in which case the resulting resin solution will again contain the linear polymers (Stage "A" or resol) that possess solubility in all stages of polymerization.

Should the lattice be obtained by the formation of three-dimensional molecules owing to primary valence bonds, with a sufficiently high degree of polymerization or polycondensation, the solubility of the resin is lost (Stage "B," or resitol), followed next by the loss of fusibility (Stage "C"—resite).

As the length of a linear polymer increases, with the transformation into a three-dimensional molecule, the mechanical properties of resultant resinoids and films obtained from them are altered, the longest chain polymers having the greatest elasticity (resilience), tensile strength and toughness.

The final Stage "C" may be regarded as the state of aggregation of elementary particles into one very large molecule, held together by the forces of fundamental valencies (Ellis).

The intermediate Stage "B" of a resinoid is characterized by the lattice network which is conditioned both by the primary and by the secondary valencies, and is met with most frequently in practice. Under the action of heat, the secondary valence bonds in a resin are broken.

The solubility, therefore, may be taken as one of the criteria of the reversibility of film-formation.

Of course, with the escape of solvent, the influence of the secondary valencies is reimposed. Residues of a solvent or plasticizer, however, alter considerably the original relationship of the secondary valence forces.

Thus, the residues of solvent, plasticizer and oil (if present), acting on the secondary valence bonds, modify the plasticity (fluidity) of resinoids and derived films.

On the other hand, elastic (resilient) properties of resinoids and the resulting coatings depend on the structural factors of macromolecules and are functions of the fundamental valence bonds.

Hence the primary cause of the distinction between films and resins with highly developed elastic features ("lastics," as Ellis termed them) and products having dominant plastic properties ("plastics") is the difference in the relationship between forces of the fundamental and the secondary valencies and their space distribution.

Three-dimensional Macromolecules

One of the distinguishing features of high molecular compounds is their ability to change sharply their physical characteristics as a result of chemical interaction with exceedingly small quantities of certain substances.

Notwithstanding, however, the significance of the above phenomenon, the information on its mechanism is extremely meagre owing to experimental difficulties. Considerable progress has recently been made by many workers in attempting to determine the nature of products obtained by interaction of minute amounts of certain materials with high molecular compounds.[9]

It has been established, for example, that the loss of solubility and fusibility (or at any rate the raising of the temperature level of softening) as a result of addition of some substances, is due to the ability of these bodies to interact with the chain macromolecules of high polymeric systems, in which event they are capable of linking the chains in space with the formation of the three-dimensional lattice.

In such a macromolecule each separate chain polymer loses its individual freedom, even when the points of contact were extremely few, yet its physical properties are distinctly different from those of separate linear molecules. For this reason, it would be justifiable to expect that materials composed of very large three-dimensional structures should be infusible on account of small specific surface of such molecules.

(To be continued.)

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